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(54) Title: SOUND ABSORPTION MATERIAL

(57) Abstract: A cementitious composition that contains water, cement mix and an aggregate that not only provides bulk, but also provides air pores for absorbing sound. The air pores are inherently present in the aggregate material, and are not completely compatible with water such that the pores are not entirely removed during the admixing process to produce the sound absorbing material. Furthermore, a gas producing compound is also provided that reacts with the cement during the initial hydration process to produce gas bubbles in the cementitious composition in order to further provide pores or voids in the composition.

SOUND ABSORPTION MATERIAL

FIELD OF INVENTION

The present invention relates generally to cementitious compositions and methods of making the same. In particular, the present invention relates to an improved cementitious composition with sound-absorbing properties and the method of producing thereof.

BACKGROUND OF INVENTION

Cementitious materials that are long lasting and have enhanced sound absorption properties while retaining fire proof properties are highly sought after.

High sound absorption properties in cementitious compositions are currently achieved, for example, through the addition of foaming agents to the composition, which results in various chemical reactions inducing the formation of gases before and during the hydration process of the cementitious materials. The addition of foaming agents to the composition generally requires a staged and complex mixing procedure as well as additional and more complicated mixing equipment. It is therefore the object of the present invention to provide a cementitious composition with high sound absorption properties without the use of complex foaming agents and which is produced in a more simplified manner.

SUMMARY OF INVENTION

Accordingly, the present invention provides a cementitious composition that contains water, cement mix and an aggregate that not only provides bulk, but also provides air pores for absorbing sound. The air pores are inherently present in the aggregate material, and are not completely compatible with water such that the pores are not entirely removed during the admixing process to produce the sound absorbing material. Furthermore, a gas producing compound is also provided that reacts with the cement during the initial hydration process to produce gas bubbles

in the cementitious composition in order to further provide pores or voids in the composition.

In the preferred embodiment, the aggregate with pores is expanded perlite or expanded vermiculite that has been pre-treated with a water repelling admixture. The cement mix includes cement such as Ordinary Portland Cement (OPC), and the necessary hardening admixture and water reducing admixtures for the standard hydration reaction to be completed and to provide early strength to the composition. The gas producing compound is preferably aluminium powder and a strengthening fiber is preferably provided for improved strength. Aluminium powder reacts with the cement mix to add voids. In the most preferred embodiment, gypsum, quicklime and a modulator/regulator are also added to the admixture.

Depending on the compressive strength of the material required and the amount of pores that are required, the combinations and quantity of the above-described elements may be determined by one skilled in the art based on the teaching as disclosed below. The present method and composition can generate on open-pore structure with void content of 15%-80% and dry density of 200kg/m^3 to 1,000 kg/m^3.

The preferred method of producing the material involves the pre-treatment of the aggregate with a water repelling admixture and/or the pre-hydration of the aggregate before it is mixed with the other constituents of the composition.

One method of producing the sound absorption material includes the steps of:

(a) Pre-treating the aggregate with a water repelling agent or using an aggregate that has been pretreated with a water repelling agent;

(b) Dry mixing the cement and fibers evenly together;

(c) Mixing the water reducing admixture, gas forming admixture, modulator/ regulator, quicklime and gypsum together with the required amount of water;

(d) Mixing the mixture in (a) together with the mixed elements in (b);

(e) Mixing the mixture in (d) with the mixture in (c).

(f) Casting and curing of the final mixture in (e).

The principal advantage of the present invention is that the cementitious composition is comprised primarily of materials readily available for the production of concrete. The sound absorption material is further produced using simplified mixing process and standard mixing equipment. A further advantage is that the sound absorption properties of the material i.e. the void content, may be controlled by varying the ratios of the various components in the composition rather than changing the mixing procedure. The wet mixture also contains a relatively low water content, rendering the mixing process relatively easy and the curing and drying process very fast.

BRIEF DESCRIPTION OF FIGURE

Figure 1 is a schematic drawing of a formed shape that can improve the sound-absorption properties of the cementitious material according to the present invention. All dimensions are in mm.

DETAILED DESCRIPTION

In the description and the accompanying claims, the terms "comprising", "including" and "containing" are meant to be open-ended in their meaning, and should be interpreted to have the meaning "containing but not limited to ....".

The preferred embodiment according to the present invention comprises the following constituents:

1. Cement mix including

(a) Cement: Sulphur Aluminate Cement or Ordinary Portland Cement;

(b) Hardening Accelerator or hardening admixture such as Iron Sulphate ($FeSO_4$), and water reducing admixture, a non-limiting example being Sikament 163 EX from Sika Hongkong Ltd. of Shatin, New Territories, Hong Kong.

2. Treated Aggregate: being expanded perlite of a maximum density of 120kg/m^3, diameter less than or equal to 3mm, and treated with a water repelling admixture to ensure a water absorption factor for the aggregate of less than or equal to 150% of the volume of perlite;

3. Water;

4. Gas Forming Admixture such as Aluminium Powder of at least 98% purity;

5. Modulator/Regulator such as Potassium Hydroxide (KOH) of at least 98% purity;

6. Quicklime: (CaO);

7. Gypsum;

8. Strengthening fibers: polypropylene fibers; and

9. Optional Waterproofing Treatment: silicone resin based treatment.

The preferred mixing proportions of the various ingredients are shown in Table 1.

Table 1

No.	Components	Range of Preferred Mixing Ratio
1	Cement: Aggregate	1:3 to 1:8 by volume
2	Water Reducing Admixture:	0.8% to 1.2% by weight of cement
3	Aluminium Powder	0.1% to 1% by weight of cement
4	Modulator (KOH)	0.06% to 0.1% by weight of cement
5	Hardening admixture (Iron Sulphate)	3% to 5% by weight of cement
6	Gypsum	0.5% to 2% by weight of cement
7	Quicklime	1.5% to 2.5% by weight of cement
8	Polypropylene Fiber	0.005 to 0.5% by weight of cement
9	Cement: Water	1:0.7 to 1:1.7
10	Compaction Factor	1.1 to 1.8

An example of the mixing procedure is shown in Table 2.

Table 2

Item	Procedure
1	Aggregate Pre-treatment: Expanded perlite is pre-treated by spraying with a nominal quantity of water repelling material until aggregate surface covered
2	Pre-Hydration of Aggregate: Expanded perlite from Item 1 above is mixed with water to achieve smooth consistency immediately prior to Item 3
3	The following constituents are mixed together in the proportions stated in Table 1 above for a period of 10 minutes or until the fibrous material is dispersed (whichever is greater) 3.3.1 Cement 3.3.2 Water Reducing Admixture

	3.3.3 Gypsum 3.3.4 Quicklime 3.3.5 Hardening admixture 3.3.6 Strengthening Fiber 3.3.7 Water
4	The following constituents are then added in the proportions stated in Table 1 above and mixed for 1 minute or until smooth consistency is achieved: 4.1 Gas Forming Admixture 4.2 Modulator/Regulator
5	The Aggregate (expanded perlite) is then added and mixing continues until the surface area of the perlite is evenly covered and the mix is of consistent colour
6	Mix can be used for application following Item 5 above

Once mixing is complete, the gas forming admixture reacts rapidly with the cement to produce gas and the mixture is immediately cast into the appropriate casting moulds and compacted to the required compaction factor. The compaction may also include the step of shaping the concrete into the desired profile. In the preferred embodiment, the gas-generating reaction of the aluminium is complete by the time the hydration process is complete.

Once the appropriate profile is formed, the cementitious composition is cured by keeping the material saturated preferably for a minimum of three days after which the cast materials may be left to air dry for a period of up to 5 days or may be oven dried for example at 110°C for 18 hours.

A water-repelling sealant such as silicone resin may also be optionally sprayed onto the dry surface of the final product to reduce the moisture absorption and enhance the durability of the material. The resultant cementitious material is an open-pore cellular structure with enhanced sound absorption properties, non-water absorbent, 100% free of asbestos mineral fibers, polystyrene and cellulose, and is 100% fire resistant. The void content of the material is 15%-80% of the dry density, with a dry density of 200kg/m^3 -1,000kg/m^3 and compressive strength of up to 4.2MPa.

A specific example of the material that may be used is shown in Table 3. A specified method of mixing the material shown in Table 3 is described in Table 4. Using the materials described in Table 3 and the method shown in Table 4, the sound absorption material would have a density of at least 560 kg/m^3, and a

compressive strength of at least 2.75MPa. It will have sound absorption coefficients that exceed the standard as shown in Table 5. A sample that was prepared to the profile indicated in Figure 1 and using the teaching in Tables 3 and 4 produced a material that was actually tested for the sound coefficient in accordance with ASTM [American Society for Testing and Materials] C423-84A "Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method" or ISO [International Standards Organisation] 354 "Standard for the Measurements of Absorption Coefficients in a Reverberation Room". The results are as shown in Table 6.

Table 3

1.	The mixing ratio of Cement to Aggregate is 30kg of cement to every 0.08 – 1 m3 of perlite. Perlite is of density of not more than 120 kg/m^3 and diameter of 0.05 – 3mm
2.	The mix proportion of the Water Reducing Admixture is 0.8% of the weight of cement
3.	The mix proportion of the Gas Forming Admixture (Aluminium Powder) is 0.7% of the weight of cement
4.	The mix proportion of the Modulator/Regulator (KOH) is 0.08% of the weight of cement
5.	The mix proportion of the Hardening Accelerator (Iron Sulphate) is 4% of the weight of cement
6.	The mix proportion of the Gypsum is 1.7% of the weight of cement
7.	The mix proportion of the Quicklime is 2.5% of the weight of cement
8.	The fibrous material ("Durafibre" by Hill Brothers Chemical Co., Orange, USA or similar) is mixed in at 0.2% of weight of cement
9.	Water – Cement ratio: 0.7 to 1.0
10.	Compaction Factor: 1.3

Table 4

(a)	Pre-treating the aggregate with a water repelling agent to ensure a water absorption factor of less than or equal to 150% of the volume of perlite
(b)	Dry mixing the cement and fibers evenly together
(c)	Mixing the water reducing admixture, gas forming admixture, modulator/ regulator, quicklime and gypsum together with the required amount of water
(d)	Mixing the mixture in (a) together with the mixed elements in (b)
(e)	Mixing the mixture in (d) with the mixture in (c)

Table 5 – Typical Standard for Sound Absorption Coefficients

Sound Absorption Coefficient						
Frequency (Hz)	125	250	500	1000	2000	4000
Coefficient	0.20	0.60	0.75	0.85	0.90	0.90

Table 6 – Actual Sound Absorption Coefficients For A Product Produced According to the Present Invention

Sound Absorption Coefficient						
Frequency (Hz)	125	250	500	1000	2000	4000
Coefficient	0.21	0.66	0.91	0.93	1.06	0.98

The other properties of the material made as described in Tables 3 and 4 are shown in Table 7.

Table 7

Property	Standard of Testing	Result
Density	ASTM E761	665 kg/m^3
Compressive Strength	ASTM E761	-4.2 MPa
Bond Strength	BS 5270 App. F	0.35 MPa
Flame Spread & Smoke Developed Values	ASTM E84-87	Zero
Non-Combustibility	ASTM E136	Zero

While the present invention has been described particularly with references to Tables 1 to 6 with emphasis on components having specific ranges as described above, it should be understood that the tables are for illustration only and should not be taken as limitation on the invention. It is contemplated that many changes and modifications may be made by one of ordinary skill in the art without departing from the spirit and scope of the invention described. For example, the cement used is preferably Ordinary Portland Cement, but other cement that are of similar properties may also be substituted. The strengthening fiber used in the

description in Table 2 is polypropylene fiber, but other strengthening fibers such as zirconium silicate fiber or combinations thereof may also be used. The preferred range of the zirconium silicate fiber is 0.05%-3% and the range of polypropylene fiber is 0.005%-0.5%, and more preferably 0.005%-0.02%.

The aggregate is preferably expanded perlite or expanded vermiculite treated with a water-repelling agent or combinations thereof. The ration of cement: aggregate is in the range of 1:2 to 1:9, preferably 1:3 to 1:8 and most preferably 1:4 to 1:5 by volume. The water repelling admixture treatment reduces the water absorption ability of the perlite or vermiculite, thus also reducing the amount of water that is required to mix with the cement properly, resulting in reduced drying time and increased strength of the final material. These are additional advantages in using the water repelling admixture besides the function of creating voids in the final sound absorption material.

The gas producing material is preferably extra fine aluminium powder, the concentration being 0.05%-1%, preferably 0.1%-0.5% and more preferably 0.3%-0.5% by weight of cement. The aluminium powder reacts with the Portland cement to give off hydrogen gas that creates voids in the final hardened composition. These voids are located in the cement, and are found in addition to the pores found in the aggregate. The combination of voids in the cement and pores in the aggregate is what gives the improved sound absorption coefficient of the product produced according to the present invention. The size and number of voids can be adjusted according to the particle size of the aggregate and aluminium powder and the amount used. As a non-limiting example, voids of 0.1mm-1mm may be produced in the hardened cement using the aluminium powder described above.

CLAIMS

1. A cementitious composition with sound-absorbing capability, said composition having pore structures occupying 15%-80% of said material and an air dry density in the range of 200kg/m^3 - 1,000kg/m^3, said composition comprising:

(a) cement mix;

(b) aggregate; and

(c) gas producing admixture;

said material characterized in that said aggregate is pre-treated with a water repelling agent to prevent a portion of said air pores from retaining water during the production process thereof; and the gas producing admixture creates void in the hardened cement mix.

2. A composition according to Claim 1 wherein said cement mix includes Ordinary Portland Cement, water reducing admixture, and hardening admixture.

3. A composition according to Claim 2 wherein said cement: aggregate ratio is in the range of 1:2 to 1:9 by volume.

4. A composition according to Claim 3 wherein a strengthening fiber is provided in the composition.

5. A composition according to Claim 3 wherein said gas producing material is aluminium powder at a concentration of 0.05%-1% of cement.

6. A composition according to Claim 3 wherein said aggregate is expanded perlite at a ratio of 1:2 to 1:9 (cement: expanded perlite by dry volume).

7. A composition according to Claim 3 wherein said fiber is polypropylene fiber at a concentration of 0.005%-0.5% by weight of cement.

8. A composition according to Claim 2 wherein said hardening admixture is iron sulphate at a ratio of 3% -5% by weight of cement.

9. A composition according to Claim 3 further comprising gypsum at a concentration of 0.5%-2% by weight of cement and quicklime at a concentration of 1.5%-2.5% by weight of cement.

10. A method of producing a cementitious sound-absorbing material containing cement, water reducing admixture, modulator/regulator strengthening fiber, aggregate, gas producing admixture and hardening admixture; said method comprising the steps of:

(a) Pre-treating the aggregate with a water repelling agent;

(b) Dry mixing the cement and fibers evenly together;

(c) Mixing the water reducing admixture, gas forming admixture; modulator/regulator, quicklime and gypsum together with the required amount of water;

(d) Mixing the mixture in (a) together with the mixed cements in (b);

(e) Mixing the mixture in (d) with the mixture in (c); and

(f) Casting and curing of the final mixture in (e).

11. A composition comprising:

(a) ordinary Portland Cement;

(b) aggregate at a ratio of 1:3 to 1:8 by volume of cement: aggregate;

(c) water reducing admixture at a proportion of 0.8% to 1.2% by weight of cement;

(d) aluminium powder at a proportion of 0.1% to 1% by weight of cement;

(e) Potassium Hydroxide at a proportion of 0.06% to 0.1% by weight of cement;

(f) iron sulphate at a proportion of 3% to 5% by weight of cement;

(g) gypsum at a proportion of 0.5% to 2% by weight of cement;

(h) quicklime at a proportion of 1.5% to 2.5% by weight of cement;

(i) polypropylene fiber at a proportion of 0.005% to 0.5% by weight of cement; and

(j) water at an amount of 1:0.7 to 1:1.17 of cement: water,

the composition further characterized in that the elements cited above are combined and compacted at a compaction factor of 1:1 to 1:8.

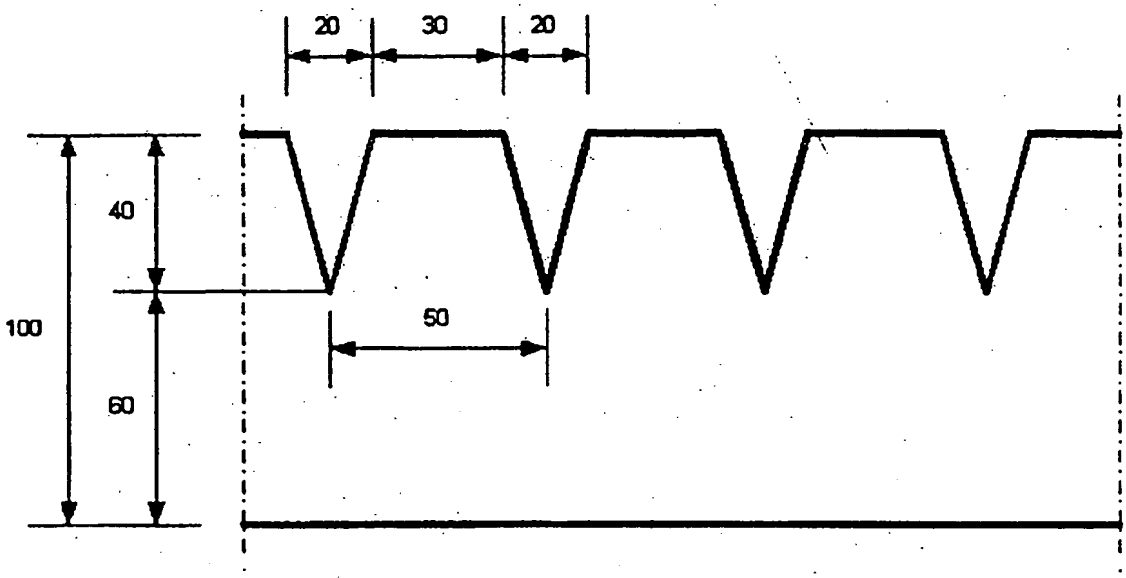

Fig.1

INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER

IPC7:C04B28/04 14/18 14/20 38/02 38/08 B28B1/14 //C04B111:52

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7:C04B B28B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/CN 6 Xitucheng Rd., Jimen Bridge, Haidian District, 100088 Beijing, China Facsimile No. 86-10-62019451	Authorized officer YU ZHONGRU Telephone No. 86-010-62093440

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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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